
Space Weather Technical Forecast

Issued on Wednesday, 06 September 2023 at 01:30 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: R1 Minor Radio Blackouts Likely 06 Sep, otherwise Chance throughout. Possible peak Slight Chance G1/Minor Geomagnetic Storm interval early current UTC day.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate in the past 24 hours, with GOES16 and 18 recording a peak M2.0 flare from AR3421, near centre-disc, at 05/0812UTC and a second M-flare (M1.2) from the same region at 05/1945 UTC. The only other significant flare was a C7.1 just beyond the northeastern limb, which may be associated with a newly arriving region. There are currently nine sunspot groups on the visible disc - the most dynamic being AR3421 and AR3423. The large and central AR3421 was responsible for the Moderate flares and continues to spread horizontally, with continued development and fading of a number of intermediate spots. AR3423 showed rapid growth, with multiple spots emerging, although the narrow viewing angle reduces confidence in analysis. Two new regions are in the process of emerging from the northeast limb, AR3425 and a separate small bipolar region.

A large Coronal Mass Ejection (CME) with partial halo was observed on coronagraph imagery at 05/1400 UTC, leaving the Sun from the far-side of the disc, beyond the northwest limb. Initial analysis of this feature does not show an Earth-directed component. However, what may be a separate CME is visible on imagery beyond the southwest limb around 05/1600 UTC and is yet to be analysed.

Solar Wind / Geomagnetic Activity: The solar wind environment was initially at slow-ambient levels around 380 km/s before a marked discontinuity was observed around 05/1438 UTC, with speeds rapidly increasing to around 430 km/s. This is considered to indicate the arrival of a CME that left the Sun on 01 September. Wind speeds have since remained at Slightly Elevated levels, 420-460 km/s. The phi angle has been largely weakly aligned towards the Sun (negative), with brief periods aligned away from the Sun (positive). The solar wind density showed a level trend within the long term background of single-figures ppcc, before suddenly increasing to Above Average upon arrival of the CME with a peak of 17ppcc around 1930UTC. Density is currently trending towards Average. The IMF was smooth until 05/0600 UTC, and then weakly fluctuated until 05/1438 UTC at which point it jumped to Moderate, with a peak of 10nT. IMF returned to weak levels around 05/1900 UTC. The north-south component weakly fluctuated until 05/1438 UTC, and again from around 05/1900 UTC. The intervening period saw fluctuations ranging between +9/-9nT.

The net result of the above solar measures was for Quiet (Kp 0-2) geomagnetic activity, then Active (Kp 4) or Unsettled (Kp 3) periods from 05/1500UTC.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux has been at Background levels throughout.

GOES16 high energy (greater than 2MeV) electron flux was predominantly at Moderate levels, increasing to High 05/1525-1720 UTC) with a peak of 1870pfu at 05/1550UTC. The associated 24-hour fluence was below the Active threshold but on a rising trend, with 4.05e7 integrated pfu

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observed at 06/0001UTC.

Four-Day Space Weather Forecast Summary

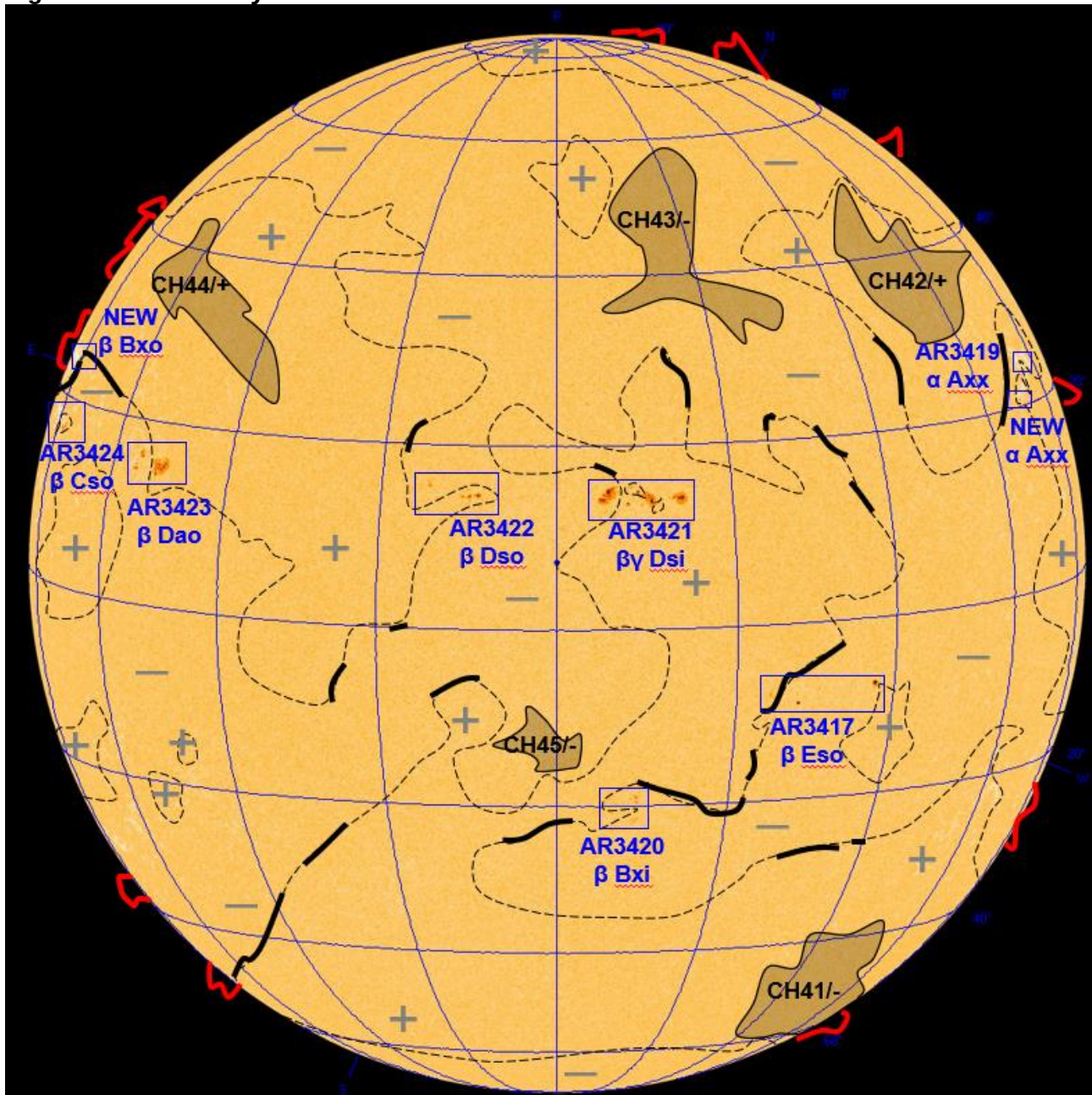
Solar Activity: M-class flares are Likely Day 1 (06 Sep), most likely associated with AR3421. There is then an ongoing Chance of M-class flares that increases slightly on Day 4 with the anticipated arrival of a returning active region, coupled with the increased complexity of AR3421.

Solar Wind / Geomagnetic Activity: The geomagnetic forecast is for a peak Slight Chance of Active (Kp 4) or G1/Minor Geomagnetic Storm (Kp 5) intervals early within the current UTC. In the absence of further CMEs, activity should remain largely Quiet to Unsettled (Kp 0-3). However, there is low confidence in slight enhancement Days 2-3 (07-08 Sep) from any contribution from CH43/- or from a potential CME glancing blow.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is Expected to remain at Background levels.

High energy (greater than 2 MeV) electron flux carries high uncertainty, and although an initial rise in diurnal flux is likely, this should soon be attenuated at GEO. Any recovery is low confidence, but on balance should perhaps most likely remain below Active throughout.

Figure 1. Solar Analysis Valid 05/2000 UTC.



Key: Filament —, Prominence —, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

The effects of the recent CME arrival are expected to wane into Day 1 (06 Sep). Although there have been a number of recent large CMEs, there is only one that is currently modelled to have a partially Earth-directed component and that may produce weak enhancement, the 04/1330UTC southeastern quadrant filament eruption. There is low confidence in the potential for a glancing blow from the shock produced by this eruption, with the bulk of the ejecta expected to pass behind the Earth late Day 2 or early Day 3 (07-08 Sep).

The high speed stream from CH42/+ was forecast to arrive on 05 Sep, however, there is no clear signal for this arrival on L1 or Stereo-A solar wind traces. Any enhancement may now be obscured by the CME arrival on 05 Sep, with winds expected to trend towards slow-ambient levels by Day 2 (07 Sep). From late Day 2, but more likely Day 3 (08 Sep) a weak HSS from CH43/- may provide some slight enhancement to solar wind speeds. The earlier fast wind is expected to be the more marked event given the approaching autumnal solar equinox with more direct alignment in addition to its having positive polarity.

In summary, in the absence of any further Earth-directed CMEs, the geomagnetic forecast should show a peak Slight Chance of Active (Kp 4) or G1/Minor Geomagnetic Storm (Kp 5) intervals early Day 1. There is then a further dampened risk of Active or G1/Minor Geomagnetic Storm intervals from any contribution from CH43/- and/or from the potential CME glancing blow Days 2-3, although both of these events are low confidence and low probability. Otherwise, activity is expected to be initially Quiet to Unsettled (Kp 0-3).

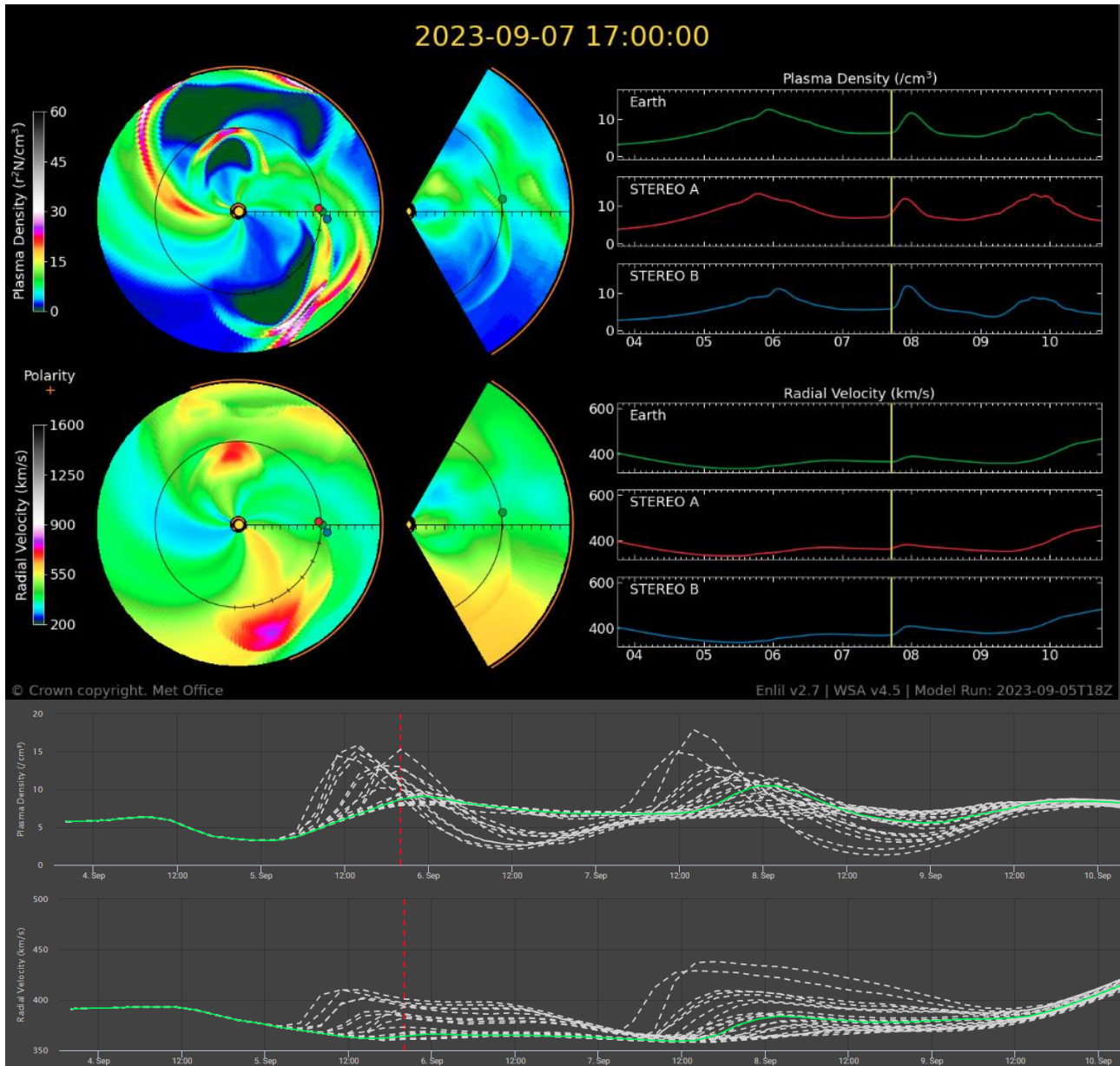
Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	15	5	5	2
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
04/1330 UTC	Partial	Flare	SE (Plage)	1025km/s	Late 07-early 08 Sep	Slight chance of glance from shock.



Figure 2: 1800UTC MOSWOC Enlil run and Ensemble, showing low confidence arrival of a glancing blow late 07-early 08 Sep. No significant contribution from HSSs observed in output.



Radio Blackouts - X-Ray Flares:

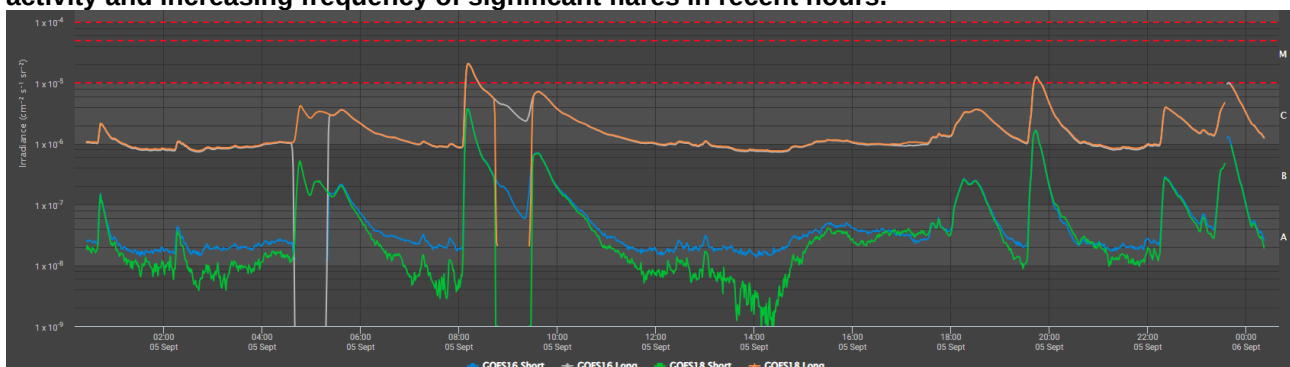
There are currently nine sunspot regions on the visible disc. The largest and most magnetically complex regions on the disc are AR3421 and AR3423. AR3421 (Dsi/Beta-Gamma), near the centre disc, continues to spread horizontally, with ongoing growth and decay of a number of intermediate spots. AR3423 (Dao/Beta) continues to grow quite quickly, but currently retains a simple Beta configuration, although the viewing angle is still limiting. AR3417 (Eso/Beta) in the southwest of the disc has been reclassified given the horizontal extent of the group, but otherwise has shown little change. AR3420 (Bxi/Beta) was recently responsible for a moderate C-flare, with a nearby filament potentially a source of instability. Two new regions have started to emerge across the northeastern limb and will be monitored as they rotate further onto the visible disc. One or more of these regions may have been the source of significant flare activity observed from just beyond the eastern limb in recent days.

No significant regions are expected to depart the disc in the period. However, there are signs from far-side soundings, Mars Persistence rover solar images as well as persistence that Ex-AR3403 may have survived its far-side transit to deliver the C7.1 observed around 05/0930 UTC, and is set to emerge (or continue to emerge) Days 1-2 (06-07 Sep). A further large region may rotate onto the disc by the end of Day 3 (08 Sep).

The sizeable arriving region and the current trend towards increasing flare activity from AR3421 are the reasons for Likely continuation of Moderate X-ray flares initially, and for an increase in flare risk again towards the end of the period as new regions emerge and/or become more geo-effective.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	40	40	50
Very Active	R3 to R5 X Class	No	2	2	2	2

Figure 3: GOES16 and 18 X-ray trace showing the X-ray flares over past 24 hours with Moderate activity and increasing frequency of significant flares in recent hours.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is within Background levels. There has not yet been any response from the recently observed M-class flares, and any exceedance of S1 is considered unlikely.

There is a nominal slowly increasing daily Slight Chance of an enhancement should any significant flares occur, with these most likely from AR3421 and perhaps rapidly-growing AR3423 or newly emerging regions in the north-east.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	5	2	2	5
Very Active	$\geq \text{S3}$ *	No	1	1	1	1

* S3 $\geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)

High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy (greater than 2 MeV) electron flux observed by GOES16 is currently at Moderate levels after a brief period at High levels 05/1525-1720 UTC. Following the recent CME arrival, electron flux levels are expected to attenuate with diurnal oscillations remaining at Moderate levels. Further enhancements to the electron belt may occur should fast winds arrive from CH42/+ and CH43/-, with a recovery in flux and fluence levels towards the end of the period. However, confidence in detail is currently low for this given up to two incident fast winds, and the potential for a CME arrival.

The associated 24-hour fluence will most likely remain below the Active ($1\text{e}8$ integrated pfu) threshold throughout the period, but with greatly decreasing confidence with time. MOSWOC REFM is considered to be giving good guidance initially, however, confidence falls through the period given the possible presence of transients.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	10	10	20	20
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 5: GOES16 high energy electron flux over past 24-hours, with increase to high levels despite suspected CME arrival around 05/1430UTC. Electons then notably suppressed.

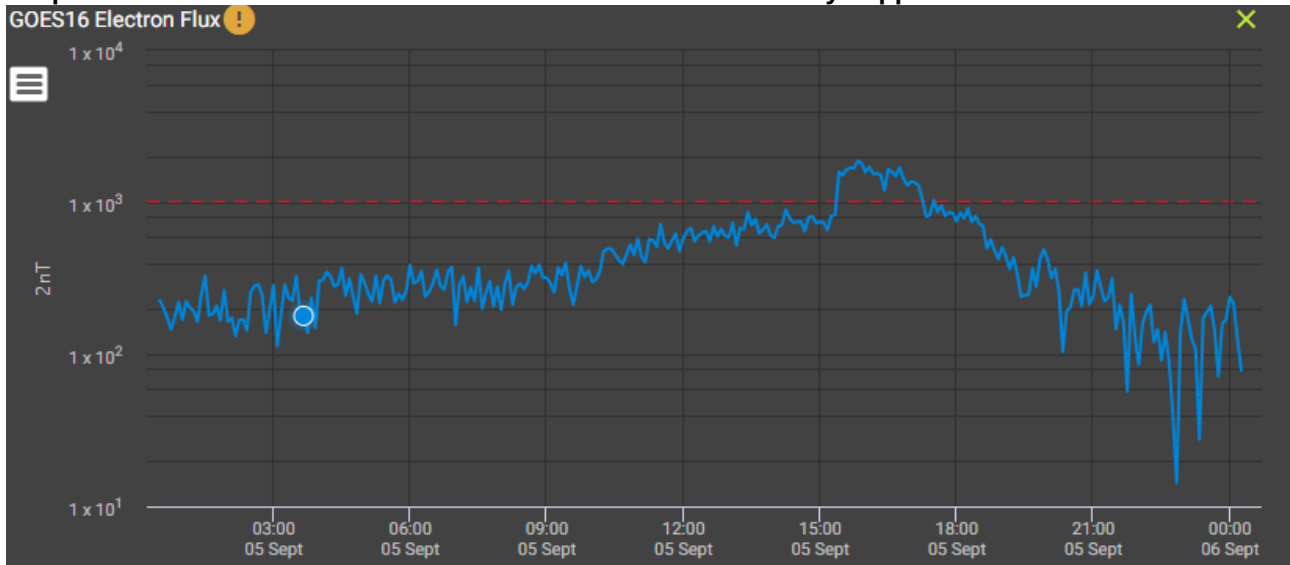


Figure 6: REFM showing reasonable guidance initially, then low confidence in forecast detail.

